Essays in International Macroeconomics

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1 Introduction

Why do we need bank capital? How much bank capital do we need? Should we spend taxpayer's money on bailing out and injecting capital to banks? These questions have gained a lot of attention since the global financial crisis of 2007-2009. The crisis was centered in the banking sector and in the general financial system and clearly demonstrated the importance of well-functioning financial intermediation. In order to avoid a collapse of the financial system, governments throughout the developed countries implemented multiple bank bailouts and recapitalization schemes. The debate about further extending such measures is still ongoing in a number of countries, like Italy, where bailouts either did not take place during the crisis or proved insufficient for banks to restructure and resume their normal lending and intermediating activity.

Ever since the crisis entered its most severe period in 2008, there has been a widespread debate about the role of the financial system in the economy and about possible reforms of the financial system. For the role of bank capital, or bank equity, the standard of the literature has been works by Kiyotaki and Gertler (2010, 2016). For the potential changes in the architecture of the financial system, some, but by far not all the issues addressed include the very shape of contracts that bank offer bank, as well as radical proposals to change banks financial structure, including much more bank capital and equity in the system (see Cochrane (2014) and Admati et al. (2013)). The consequences of potential bank bailouts and increasing the amount of bank capital has been recently analyzed in the literature, for example by Begenau (2016).

Financial intermediation based on debt and deposit contracts is a common feature of modern market economies. A large part of consumers financial assets is held as of bank deposits. Similarly, many firms rely on bank credit to finance new projects. Most consumers don't have access to all the productive projects in the economy. They may also lack the knowledge or the ability to monitor the activities of firms they invest in, and need specialized institutions to perform these activities, as discussed by Bernanke and Gertler (1989) and subsequent work. Since banks may be seen as institutions that help to overcome these information asymmetries and help allocate consumers resources in projects and firms where they are most productive, bank play a large role in increasing economy's overall efficiency. These gains may then be passed on to consumers in form of interest payments on deposits. Note that at this point banks also play a role in transforming the cash flows they receive from firms or indebted households in form of diverse return on loans, equity and other contracts, into simple debt contracts they operate with consumers. Thus, they allow consumers who may otherwise lack expertise or information access to indirectly benefit from the productive projects the banks invest in.

The aim of this work is to provide a framework to think about contracts offered to consumers by financial intermediaries and the way they depend on equity (capital) held by these intermediaries. I assume that bankers play a productive role in the economy as they have access to better investment opportunities than the general public (consumers), either by access to monitoring technology, or by better access to information, perhaps by centralizing the intermediating activity. It would then seem desirable that bankers would somehow allow consumers to access their technology, as this would allow the economy as a whole to produce higher output and most likely increase welfare of all agents. However, I assume that there is an information asymmetry between the banker and the consumer, since the return on projects operated by bankers is only observed costlessly by those bankers. In order for consumers to verify the returns, a cost must be incurred in that some part of the output is forfeit, as in work of Townsend (1979) and Chari and Kehoe (2016). This leads to a problem of designing a contract between consumers and bankers that would allow consumers to invest in bankers technology. It turns out that an optimal contract takes the form of a deposit contract with bankruptcy. Specifically, the banker promises to pay a certain amount of consumption good to consumer unless a return on the productive technology makes it unfeasible for the banker to deliver this return. If this happens, the banker declares bankruptcy, the realization of return is verified, and all the output net of bankruptcy costs is allocated to consumer.

A crucial feature of the model is that the consumer (depositor) has an outside option of a less productive "storage" technology and is not compelled to deposit all her endowment with the banker. She will only do so if the terms of the contracts offered by the banker are attractive enough. This is where bank capital plays the crucial role. I assume that while investing in the productive technology, the banker invests her own endowment together with the amount received from the depositor. If banks hold enough capital, then the amount of bank assets relative to depositor's contribution is sufficiently large, and banks will be able to offer better more attractive contracts to consumers: "more attractive" meaning a combination of lower probability of bankruptcy, as bank capital serves as a cushion against unfavorable realizations of returns on production, and a higher expected return on deposits, due to avoiding the costs of potential bankruptcies. As contracts offered by banks are more attractive, banks will now be able to attract more deposits, which will further increase the expected output in the economy and potentially allow to achieve an allocation of resources in production that would be chosen if consumers could directly access the productive technology.

I then proceed analyze the optimal size of the banking sector in the economy by allowing the planner to allocate resources between consumers and bankers by redistributing their endowments before they sign contracts. This is equivalent to bank recapitalization financed by a tax on consumers. I find out that if the technology operated by bankers is sufficiently attractive relative to technology operated by consumers, then such transfer may be desirable even if planner cares only about consumers. Namely, the better access to the productive technology through attractive contracts offered by well-capitalized banks may outweigh the cost of less resources available to consumer after the tax is implemented. Since the model is highly stylized, it is not yet ready to be brought directly to data. However, since it develops the features of bank deposit contracts as optimal contracts addressing a particular information friction and shows how this contract depends on bank capital, I believe it provides a useful framework to think about the role of bank capital and bank bailouts.

The rest of the chapter is organized as follows: Section 2 describes the environment. Section 3 establishes the properties of the optimal contract. Section 4 then analyzes the decision problem of the depositor facing this optimal contract. Section 5 describes the equilibrium in the model. Section 6 then sets up a numerical experiment and provides a solution to the model for different values of bank capital. Section 7 deals with a modified problem of a planner who can distribute the resources between banks and consumers before they sign contracts in order to maximize consumer's welfare. Section 8 concludes.

2 Environment

The overall environment is a two-period model with two types of agents. The two types are called banker and consumer (or depositor), and there is a measure one of each type. Both types begin with an endowment of an investment good, equal to one for each consumers and n for each banker. n is a central variable of interest in the model, and will be referred to interchangeably as bank capital or bank equity. There are two periods in the model, $T = \{1, 2\}$. In the first period, agents are free to sign contracts between themselves and make the allocation decisions. In the second period, a random shock to return on a risky technology is realized, production takes place, contracts are executed and agents consume their income.

Bankers are risk neutral with a linear utility function over consumption. They operate a productive technology with a stochastic return described below. Consumers are risk-averse with a utility function u that is strictly concave, differentiable and satisfies the usual Inada conditions. Consumers have access to a "storage" technology, which transfers a unit of endowment in period 1 into a unit of consumption good in period 2. Alternatively, consumers can sigh contracts with bankers so that consumers transfer some of their endowment to bankers, bankers then invest it together with their own endowment in their own "productive" technology, and then return some or all of the output to consumers as specified in the contract. .

The productive technology operated by bankers is assumed to have constant returns to scale. It yields a gross stochastic return R for each invested unit. The returns on the technology follow a distribution $F(R)$ with support $R \in (0, +\infty)$ and a continuous density $f(R)$, assumed to be strictly positive over the whole support. In order to make the following contracting problem non-trivial, I assume that $\mathbb{E}[R] > 1$- i.e. the technology is "productive" in a sense that in expectation it yields strictly higher return than storage. I assume that the realization of R is identical for all bankers and thus can be thought of as an aggregate shock. Alternatively, one could think about it as a return on a portfolio of assets managed by a bank, with each bank holding the exact same portfolio. For the sake of simplicity, I will take the distribution of R as given and will not deal with asset management decisions of bankers.

If consumers decide to transfer some resources to bankers for investment, bankers pool these resources with their own for investment in the stochastic technology. Once R is realized, bankers are the only agents in the economy who can observe it costlessly. In order to make the realization of R observed by consumers, bankers must incur a cost equal to a share $(1-\mu)$ of total output from production, with $0 < \mu < 1$. That is, if A is the total amount of goods invested in the productive technology, then RA is the realized output of consumption good, and μRA is the amount that can be distributed between banker and consumer if the value of R has been verified by consumer.

The amount of endowment given (deposited) by consumer to a banker, as well as the way the proceeds from production are distributed are specified in a contract whose terms will be derived later. In general, I allow contracts to take any form, but prove that they take the form of deposit contracts with bankruptcy. Specifically, after production, the banker pays a pre-agreed fixed amount to consumer unless the return on the risky technology is less than the specific return $\tilde{R}$, in which case consumers receive all the proceeds from production net of bankruptcy (verification) costs. To sum up, bankers first gather deposits (denoted as d) from consumers and then invest them together with their own endowment n in the productive technology. After R is realized, the total amount of resources available is $R(n+d)$. This is then shared between banker and depositor according to the contract, possibly also incurring the verification costs.

3 Optimal contract

As specified before, I allow consumers and bankers to enter any contracts they want. However, since the expected return on bankers technology is strictly higher than the return on consumer's technology and bankers are assumed to be risk averse, the only mutually beneficial contract may involve transfer of resources from consumers to bankers for bankers to invest it in their own technology. In this sense, this is a model of financial intermediation. Moreover, the fact that consumers can only observe the realization of R after incurring a cost[1] implies that the optimal contract will take a very particular form, namely, a deposit contract with bankruptcy, similar to Townsend (1979) and Chari and Kehoe (2016). A contract is specified by $x_1 = (d, S, g(R), C)$, where d is the amount (deposit) the consumer transfers to a banker in the first period, S is the set of realizations of R for which there is to be verification (with a complement set S'), $g(R)$ is the transfer from banker to consumer in period 2 when there is verification, and C is the transfer from banker to consumer if there is no verification. Since the transfer from banker to consumer cannot depend on R if there is no verification, it is an amount constant for every $R \in S'$. Moreover, since it is the banker who decides whether to submit to verification, this places an additional restriction on possible payoffs. Finally, similar to Chari and Kehoe (2016), I will require contracts to be immune to renegotiation, which means that once d is fixed, there is no other feasible and incentive compatible contract $x_2 = (\tilde{S}, \tilde{g}(R), \tilde{C})$ that makes both consumers and bankers better off, with at least one of them strictly better off. Hence, without loss of generality, I will restrict my attention to contracts immune to renegotiation and consider a contracting problem that treats d as given. Since both d and n are fixed once the contracting problem is set, let $A = d + n$ be a total amount of investment in the productive technology. Finally, let $s = 1 - d$ be the amount that consumer decided to store. The contracting problem is then to maximize consumer's expected utility subject to feasibility, incentive compatibility and a minimum level of utility promised to a banker:

Problem 3.1:

$$\max_{S, g(R), C} \{ \int_S u(s + g(R)) dF(R) + \int_{S'} u(s + C) dF(R) \}$$

[1] Whether the cost is paid by banker or by consumer is not relevant

subject to:

$$\int_S \{\mu R - g(R)\} dF(R) + \int_{S'} \{R - C\} dF(R) \geq K \qquad \text{(banker's utility)}$$

$$\mu R - g(R) > R - C \forall R \in S \qquad \text{(incentive compatibility)}$$

$$C > 0, C \leq R \forall R \in S', 0 \leq g(R) \leq \mu R \forall R \in S \qquad \text{(nonnegativity)}$$

A natural, but certainly not the only choice for the minimum level of utility that has to be guaranteed to the banker would be $K = \mathbb{E}[R] \cdot n$, i.e. one making the banker indifferent between engaging in the contract and autarky, i.e. taking her endowment and operating the productive technology independently. Incentive compatibility condition requires that in each state when the banker is supposed to be subject to verification she finds it beneficial to do so. Note that a simple rearrangement of the IC constraint implies a relationship for payoffs for consumer in verification versus non-verification states:

$$g(R) < C - (1-\mu)R < C \forall R \in S$$

where the second inequality follows since $C > 0$ and $0 < \mu < 1$. This relationship comes useful in the accompanying proofs.

Characterizing the solution to this problem, I first prove that, as typical for models with costly state verification, the verification set is the set of values of R below a certain threshold $\tilde{R}$. This is formally stated in a lemma below:

Lemma: Any solution $S^\star, g^\star(R), C^\star$ to Problem 3.1. has the property that $S^\star = \{R : R < \tilde{R}\}$ for some $\tilde{R}$.

Proof: See Appendix.

Moreover, since consumers are assumed to be risk averse, I prove that the optimal contract has the following features:

Theorem 1: Any solution to problem has the following properties: $g^\star(R) = \mu AR$ and the cutoff level $\tilde{R}$ is determined as $\tilde{R} = \frac{C}{A}$.

Proof: See Appendix.

The theorem states that if the banker announces bankruptcy, then all the output from production net of verification costs is given to the consumer and the payoff to the banker equals zero. Second, banker only subjects to verification if she cannot meet the payment C promised to consumer under no verification. Due to this fact that verification is tied to banker's payoffs satisfying feasibility condition, I will further refer to it verification simply as "bankruptcy".

It is worth noting that proofs above rely heavily on the assumption that the contract with the banker is the only source of variability in consumer's consumption. However, this assumption could be relaxed as long as other sources of variability in consumption, like idiosyncratic risk on storage technology, are independent of R.

Before proceeding further, let us slightly redefine our variables. Since the above analysis was performed under the assumption of no renegotiation, the amount of resources contributed by the depositor (and the banker) was treated as given. However, depositor's decision about whether to enter into the contract with the banker is a continuous choice variable rather than simple "participate or not" choice. Therefore, let us redefine contract variables in terms of consumer's contribution (deposit) d and banker's own capital n. As we discussed before, the total amount of assets invested in the productive technology is $A = d + n$. Let us normalize the fixed transfer in to the consumer no-bankruptcy states by the amount of resources contributed by the depositor as $r = \frac{C}{d}$. This way, r can be interpreted as the (gross) interest rate, or a promised rate of return on consumer's deposit.

To sum up, the contract is now defined as as $x_3 = (d, \tilde{R}, r)$, where d is the size of the deposit a household puts in the bank, $\tilde{R}$ is the value of R below which the bank declares bankruptcy, and r is the gross rate of return on d that the bank pays to the consumer if there is no bankruptcy. In short, the payoffs are given by:

If $R \geq \tilde{R}$ and there is no verification:

$$\begin{cases} rd & \text{for the depositor} \\ R(n+d) - rd & \text{for the banker} \end{cases}$$

and if $R < \tilde{R}$ and the bank declares bankruptcy:

$$\begin{cases} \mu R(n+d) & \text{for the depositor} \\ 0 & \text{for the banker} \end{cases}$$

Having characterized the optimal contract, we can now proceed to depositor's portfolio problem.

4 Depositor's problem

We will now specify the problem of a depositor who takes the terms of a contract as given. Formally, this problem is a portfolio problem of allocating consumer's endowment between one-to-one storage and making a deposit with the banker. Since I assume an environment in which both bankers and consumers are atomistic and identical, I assume that the depositor does not internalize the impact she has on bank's payoffs. In particular, consumer treats the amount of deposits in the bank, denoted as D, as given[2]. This is relevant for the terms of the contract since payoffs to the consumer in case of bankruptcy, as well as the bankruptcy threshold $\tilde{R}$ both depend on the amount of deposits. Since consumer treats both the bank capital n and the amount of deposits D as given, this is equivalent to saying that she takes the whole capital structure as given. Thus, I will take consumer's choice d and only compare it to average (or total, since I assume mass one of depositors) deposit D when analyzing her choice. That individual deposits equal aggregate ones will only be imposed later as an equilibrium condition.

Since n and D are already given as the aggregate state of the economy, the only variable necessary to describe the terms of the contract is the interest rate r, paid if there is no bankruptcy. Given this and the aggregate state and the form of the optimal contract derived in the previous section, the other terms of the contract, namely the bankruptcy cutoff $\tilde{R}$ and payoffs in case of bankruptcy can be determined by the consumer without need to specify them any further. Finally, since both storage and banker's technology are deal with actual goods, I exclude negative storage or consumer borrowing from the bank.

Given n and D, which together form the aggregate state for this economy, and the contract offered to her by banks, summarized by r, consumer solves for portfolio maximizing her expected utility:

Problem 4.1:

$$\max_{d\in[0.1]} \int [u(c(R))]dF(R)$$

where:

$$c_D(R) = \begin{cases} (1-d)+rd & \text{if } R \geq \tilde{R} \\ (1-d)+\frac{d}{D}\mu R(n+D) & \text{if } R < \tilde{R} \end{cases}$$

[2]This is a notion very similar to "little k" and "capital K" in a neoclassical growth model.

After substitution, depositor's problem can be shortened to:

$$\max_{d\in[0,1]}\left\{\int_0^{\tilde{R}}[u(1-d+d\mu R(\frac{n+D}{D}))]dF(R)+(1-F(\tilde{R})[u(1-d+rd)]\right\}$$

Assuming the solution is internal, i.e. $d \in (0,1)$, the first order condition for the depositor is then:

$$\int_0^{\tilde{R}} u'(1-d+d\mu R(\frac{n+D}{D}))(1-\mu R(\frac{n+D}{D}))dF(R)=(1-F(\tilde{R}))(r-1)u'(1+(r-1)d)$$

This condition requires the consumer to balance two forces that emerge as the amount deposited with the banker increases: on one hand, as in the RHS of the FOC, if $r>1$, depositing more of the endowment in a bank allows to increase consumption in states without bankruptcy. On the other, in particular for realizations of R for which $\mu R(\frac{n+D}{D})<1$, there is a loss of utility in states associated with bankruptcy.

Since the choice of d is constrained to fall between 0 and 1, corner solutions should also be discussed. The corner with $d=0$ is not very interesting and can be easily discarded if the technology operated by the banker is sufficiently attractive. This would at the very minimum require $\mathbb{E}[R]>0$, which could then hopefully allow bankers to offer contracts with an expected payoffs strictly above one and therefore attract at least some deposits from consumers. The second corner with $d=1$, where depositors have all their endowments intermediated by bankers is a more interesting one. This is a solution more likely to occur if the productive technology is sufficiently attractive relative to storage and its occurrence is likely to create "kinks" in terms of equilibrium contracts seen as a function of bank capital, as will be shown in following section. From an analytical point of view, it is important to point to a condition necessary for a $d=1$ corner to be a solution. Since u is assumed to satisfy Inada conditions of $\lim_{c\to 0}u(c)=-\infty$ and $\lim_{c\to 0}u'(c)=+\infty$ and zero is assumed to be a lower bound of the support of R, for $d=1$ to be a solution we have to guarantee that the probability of extremely low realizations of R is low enough, i.e. that the left tail of the distribution is thin enough. Consider the limit of the integrated function in the first term of the objective function as R approaches zero and $d=1$:

$$\lim_{R\to 0}u(\mu R(\frac{n+D}{D}))f(R)$$

The overall limit depends on the interaction of two terms: utility associated with extremely low realizations of R, for which$\lim_{R\to 0} u(\mu R(\frac{n+D}{D})) = -\infty$ by Inada condition, and $\lim_{R\to 0} f(R)$. For the overall limit to be finite, it is necessary (but not sufficient) that $\lim_{R\to 0} f(R) = 0$. Among others, this implies that this corner solution is not feasible if the distribution of R is uniform. For the overall limit to be finite, we basically need the density function to approach zero "faster" than the utility approaches negative infinity as R goes to zero, or:

$$\lim_{R\to 0} u(\mu R(\frac{n+D}{D}))f(R) < M$$

for some $M \in \mathbb{R}$. Economically, this condition states that the probability of extremely low realizations of R is low enough to be disregarded by a risk-averse consumer, or that at least it can be given a finite value when expected utility is considered. In the numerical experiment below, I assume the utility function to be CRRA and the returns to follow a log-normal distribution. It can be shown that for these functional forms, the above condition holds[3]. Also, it is clear that for the $d = 1$ to be a possible solution, $\mu > 0$ is also necessary.

5 Equilibrium

Having defined and characterized consumer's problem in the previous section, we can now define the general equilibrium in this economy. An equilibrium object (equivalent to a price) that determines the allocation of resources is the equilibrium contract. This, given the aggregate state of the economy n, as discussed above, can be summarized by the promised interest rate in case of bankruptcy, r. The other terms of the contract are then made clear through their relationship with r and the aggregate state. In order to determine r, it is necessary to specify the market environment that banks operate in. I assume that the banks operate competitively. In this environment, the terms of the contract are determined by banker's outside option, i.e. operating the productive technology only with their own endowment. This condition, equivalent to a standard zero profit condition, is formally stated as:

$$\int_{\tilde{R}}^{+\infty} \{R(n+D) - rD\} dF(R) = n \int_0^{+\infty} R dF(R)$$

Right hand side is simply the expected revenue if bankers just operate their own technology in isolation, $n \cdot \mathbb{E}[R]$. The left hand is the expected revenue from offering equilibrium contracts at price r. Note that I have omitted the integral from 0 to $\tilde{R}$ since by the feature of the equilibrium

[3]This is shown by applying l'Hospital rule to a slightly rearranged version of this limit for n times, where $n \geq \sigma$ where σ is the relative risk aversion parameter in the utility function

contract, the revenue of the bank for these realizations of R equals zero by the theorem proved in section 3 - these are the realizations of R for which the banks declares bankruptcy. Hence, $\int_0^{\tilde{R}}(\mu R - g(R))dF(R) = \int_0^{\tilde{R}} 0 dF(R) = 0$.

As we have specified the depositor's problem in the previous section and introduced the optimal contract and the market environment, we can now define the competitive equilibrium in this economy.

Definition: A competitive equilibrium in this economy given state n is given by a contract $(r, \tilde{R}, g(R))$, an aggregate policy D and by a policy function by consumer d such that:

- Given n, D and r, the bankruptcy cutoff $\tilde{R}$ in the equilibrium contract is determined by:

$$\tilde{R} = \frac{D}{n+D} r$$

- Aggregate policy for D is determined by:

$$D = \Gamma(n)$$

- Given n, D, and the equilibrium contract, d solves depositor's portfolio problem:

$$\max_{d \in [0,1]} \left\{ \int_{R_{min}}^{+\infty} [u(1 - d + d\mu R(\frac{n+D}{D}))] dF(R) + (1 - F(\tilde{R})[u(1 - d + rd)] \right\}$$

- Given n, D, and the equilibrium contract, bankers participate in the market and make zero economic profits:

$$\int_{\tilde{R}}^{+\infty} \{R(n+D) - rD\} dF(R) = n \cdot \mathbb{E}[R]$$

- Consistency condition:

$$d = D$$

Since in section 3 I've proved that given endowments and information frictions, the contracts in this economy are indeed optimal, this implies that the competitive equilibrium in this economy is efficient.

Table 1: Parameter values

Symbol	Value	Comments
σ	5	Risk aversion parameter
μ	0.8	Share of resources recovered from bankruptcy
Technology:		
μ_R	0.02	Return distribution: log-normal
σ_R	0.05	Mean return: 1.02, Standard deviation 0.05

Theorem 2: Given endowments, competitive equilibrium is efficient.

At this point, it is important to emphasize a dual role that bank capital plays in this model. First, when operated by bankers, it is used directly as input for production. Second, and more important for us, it allows bankers to offer better contracts to depositors. Since the realization of the productivity shock is only observable by bankers and its verification by customers requires a cost, a higher level of equity allows the banker to either promise higher rates of return to consumers, or allows her to fulfill her promises for a larger set of realizations of R before the bank runs out of funds and is forced to declare bankruptcy. Essentially, bank capital serves as a cushion against unfavorable realizations of output shock. Since customers are aware of this, then a larger amount of bank capital makes contracts offered by bankers more attractive to depositors, and therefore induce them to deposit more of their funds in the bank. Since the technology operated by bankers is more productive than the storage technology operated by depositors, some amount of bank capital may allow the economy as a whole to approach an allocation of resources in production identical to one that consumers would choose had they have direct access to the productive technology.

6 Numerical Exercise

6.1 Choice of parameters

Since the analytical solution to the above model is extremely cumbersome, in order to characterize the behavior of the model I turn to a numerical experiment instead. This is to illustrate the behavior of the model for different values of bank endowment and to check how the allocation and terms of an equilibrium contract change as I increase the value of bank capital. Since the model presented in this chapter is mostly illustrative, I do not target any particular moments in the data and only choose parameter values deemed reasonable. Values of parameters are presented in Table 1.

Consumer preferences are assumed to follow a standard CRRA utility function $u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$ with the risk aversion $\sigma = 5$. This is somewhat higher than standard estimates, but still falls within a reasonable range. On the other hand, its value is lower than what is sometimes assumed in financial literature. Moreover, it partially compensates for the fact that the storage technology is assumed to be completely safe, which is a useful normalization in terms of presenting the model, but is unlikely to hold in reality. In practice, we would rather think of bank deposits as helping to avoid some idiosyncratic risks through diversification rather than generating risks on their own. In any case, changing the value of σ parameter does not affect the qualitative results of the model.

I assume the returns on bank assets (output of the productive technology operated by bankers) follow a log-normal distribution with parameters (μ_R, σ_R). In the exercise below, I've chosen the parameters to make the productive technology only a little better than the storage technology operated by consumers. Specifically, I chose $\mu_R = 0.02$ and $\sigma_R = 0.05$. This leads to mean return on the technology to be 1.0215 with standard deviation of 0.0511. In particular, this implies that the return on the productive technology is higher than the return on storage with probability of 65.5%.

It is also worth noting that for these technology parameters, an optimal solution to a problem in which household had direct access to the productive technology and did not have to rely on intermediation neither had it faced bankruptcy costs, features all resources being directed in the productive technology. Although we should not put too much emphasis on the frictionless problem, it may still serve as a benchmark at least in terms of whether the environment with frictional environment features the same allocation of resources in production.

Finally, I choose the parameter associated with bankruptcy costs as $\mu = 0.80$. This implies that if the bank announces bankruptcy, 20% of its resources are lost and the rest can be returned to households. I deem this to be a relatively conservative value in that the bankruptcy costs are not excessively large. Note that the bankruptcy costs do not translate directly into recovery rates since recovery rates in this model would be computed against promised payment, rd, and not realized return on assets, $R(n+d)$ and would almost always be smaller thanμ. The value of μ of 0.8 still seems reasonable and potentially even high, since historic recovery rates for financial firms have been much lower at about 25% (see Mora (2012)). On the other hand, since bankruptcy state in my model corresponds more closely to a systemic banking crisis rather than to a bankruptcy of an individual bank, a higher recovery rate seems more applicable.

Reassuringly, qualitative features of the model remain stable for different values of parameters.

6.2 Results

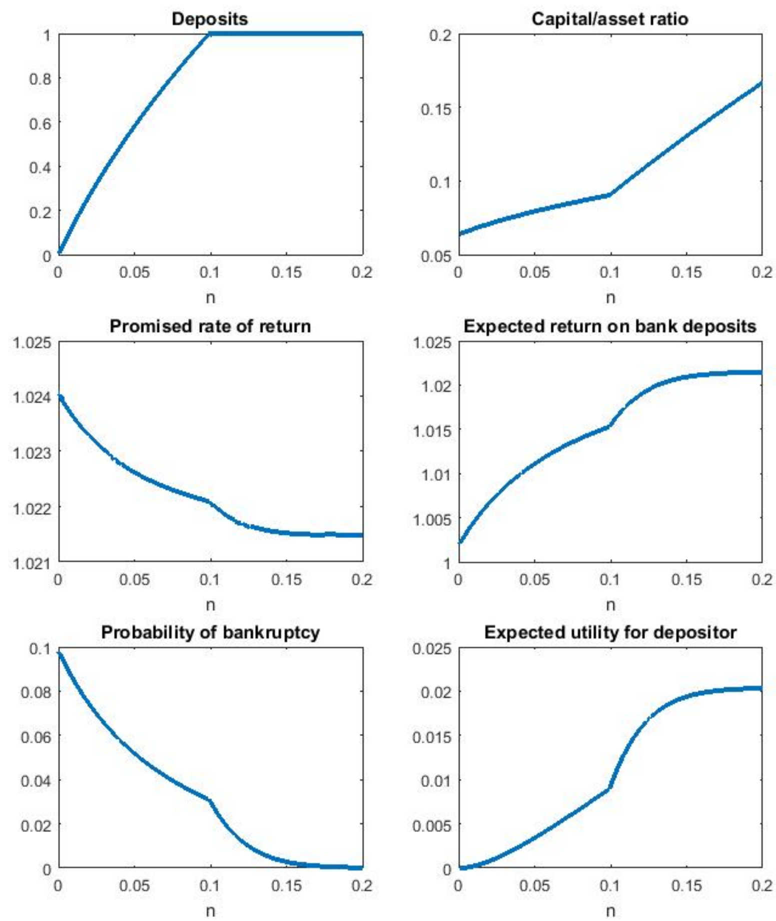
After setting the parameters as described in the previous section, I solved the model separately for different values of bank endowment n, holding consumer's endowment constant at 1. This exercise provides comparative statics for different "sizes" of the banking sector in the economy.

Since the competitive equilibrium was proved to be efficient given the information frictions, the model was solves as a social planner's problem, assuming the equilibrium contract as given. I would first solve the depositor's problem for a given choice of r utilizing consumer's first order condition. The equilibrium condition on aggregate deposits being equal to individual choice is only imposed after the FOC is specified. Having solved the model for a given value of r, I would then proceed to finding a value of r which satisfied the zero-profit conditions. Since the equilibrium is efficient, this is also the value which maximizes consumer's welfare. I would then proceed to solving a model for an alternative set of endowments. The summary of the results is presented in Figure 1.

As expected, terms of the equilibrium contract and consumer's welfare increase with the value of n. Also, the amount that consumers choose to deposit in banks increases with n, up until the point when they find it optimal to allocate all their endowments in banks. After reaching this point (for $n = 0.0995$ under my parametrization), the optimal allocation achieves the upper corner ($d = 1$) and there is a visible "kink" in the solution to the model for values of n below and above this value. Let us denote this value as $n^{\star}$. For $n \geq n^{\star}$, the allocation of resources in production is what I will further call "full intermediation" - all investment in the economy is managed by bankers, and the expected output is maximized.

For low values of n, corresponding to a small or undeveloped banking sector, the equilibrium contracts have very "risky" features: high promised returns and high probability of bankruptcy. The form of the contract makes it impossible for banks to pass on high realizations of R onto consumers. Also, the amount of bank capital is insufficient to provide much of a cushion against unfavorable realization of a shock. As a result, due to a large probability of bankruptcy, the actual expected rate of return on deposits is actually low despite higher promised rates of return. As we compare economies with successively higher values of bank equity, the contracts are becoming "safer" so that the probability of bankruptcy falls, promised returns on deposits decrease, but the expected return on deposits still increases. As contracts become more attractive, banks are able to attract more deposits. This leads to a somewhat slower growth in the capital/asset ratio, $\frac{n}{n+d}$ as a function of n, since as n

Figure 1: Equilibrium for different values of n



increases, equilibrium value of d increases as well. Overall, I believe that the features just discussed do resemble the most important features of banking sectors in developing economies.

As the amount of bank capital in the economy reaches the critical level $n^\star$, full intermediation becomes possible and banks are able to offer contract attractive enough to convince consumers to deposit all their endowments. Since productive technology has a higher expected return, this allocation achieves maximum expected output possible in this economy. However, as n increases above $n^\star$, terms of contracts offered to consumers improve further. The probability of bankruptcy falls and the expected returns on deposits increase. This results from the fact that as n becomes larger, banks are able to withstand more and more unfavorable output shocks without having to declare bankruptcy and reducing the total amount of resources by bearing the bankruptcy costs. Since banks are assumed to follow a competitive behavior, benefits of less bankruptcy in the economy are passed on to consumers. Moreover, since after full intermediation has been achieved, the improvement in terms of contracts is no longer slowed down by an inflow of new deposits, so the improvement in the terms of contracts actually accelerates for values of n above $n^\star$. It is also worth noting that as n becomes very large, then the probability of bankruptcy approaches zero and the promised (and expected) rate of returned offered by banks approaches $r = \mathbb{E}[R]$. This is the value and contract terms that would have been offered were the banks not facing a non-negativity constraint - banks, risk-neutral agents, would assume all the risk in the economy, and consumers, risk-averse agents would be offered a completely certain outcome.

Finally, we should note that as I increase bankers endowment, depositors expected utility increases as well. This finding is not particularly surprising as by increasing n and holding depositor's endowment constant, the overall amount of resources in the economy increases. In most models featuring any kind of exchange this is expected to benefit both agents. This will be changed in the next section.

7 Optimal amount of bank capital

Let us change the problem slightly. Instead of keeping consumer's endowment constant and increasing the endowment of the banker like in the previous section, suppose now that there is a unit endowment in the economy as a whole. This unit can be distributed between banker and depositor at the beginning of the period. After allocating the endowments, bankers and depositors are free to sign contracts between them as in the previous section. Is there a possibility that moving some resources away from consumer and giving them to a banker increases consumer's welfare?

This is an important question. In terms of the actual economy, it corresponds to a situation when government may choose to tax depositors in order to inject capital into banks, a feature of banking crises we often observe (see for example Laeven and Valencia (2013)). Note that in such an environment, the government does not interfere with private contracts since it does not have the ability to overcome information asymmetries present in the model, nor is there an externality that needs to be corrected once endowments are allocated - once endowments are fixed, the competitive equilibrium endowments is in fact efficient.

Formally, the planner's problem is to choose to allocate the unit endowment in the economy between bankers (n) and consumers (e), given the equilibrium price functions and allocations as functions of the endowments. Since $n+e=1$, it is enough for the planner to pick only one of these parameters. Let $u^\star$ be the utility attained by consumers in a competitive equilibrium as a function of endowments. Planner's problem is given by:

Problem 7.1:

$$\max_{e,n} u^\star(e,n)$$

subject to: $$e+n=1$$

given e and n, $(r,\tilde{R},g(R)), d$,and D are a CE as defined in Section 5

Note that this is a rather extreme version of planner's problem, as all the Pareto weight is put on the consumer. Still, we may wonder if it is desirable for the planner to allocate resources from consumer to the banker. The tradeoff the planner faces is the following: decreasing e has a simple effect of lowering the amount of resources at consumer's disposal. On the other hand, though, it allows the banker to offer better terms of the deposit contract, which then allows the consumer to participate in the more productive technology operated by the banker. If the technology is sufficiently attractive, then the loss from the lower total amount of resources at consumer's disposal may be outweighed by the gain from access to a more attractive contracts.

Again, to check if such a situation is possible, I turn to a numerical exercise, solving for a competitive equilibrium for different distributions of endowment. As it turns out, for the parameters used in section 6, the loss of consumer's resources dominates the gain from better contracts. Note, however, that for the parameters chosen in that section, the productive technology was not much better than storage. After experimenting with different parameters of the productive technology,

Table 2: Updated parameter values

Symbol	Value	Comments
σ	5	Risk aversion parameter
μ	0.8	Share of resources recovered from bankruptcy
Technology:		
μ_R	**0.12**	Return distribution: log-normal
σ_R	0.05	Mean return: **1.129**, Standard deviation 0.056

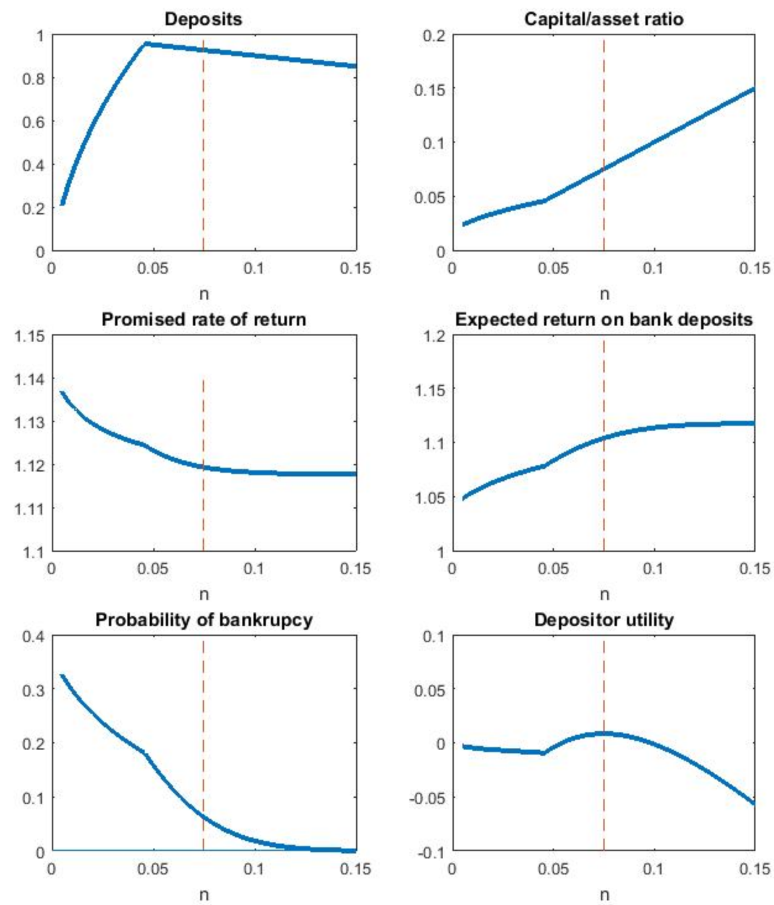
it turns out that shifting the distribution to the right by increasing the parameter μ_R, this tradeoff changes significantly. The new values of parameters are presented in Table 2.

The only change in new parameters relative to old ones is the value of location parameter μ_R. The solution to problem 7.1. for this set of parameters is shown on Figure 2.

For the values of parameters assumed above, a very interesting picture emerges. Overall, the results are similar to those discussed in Section 6, with similar patterns for deposits, expected return on bank deposits and probability of bankruptcy. Again, there exists a value of bank capital $n^\star$ for which consumers decide to deposit all their endowments with bankers. As n increases, the terms of the contract offered to consumers also improve, with the promised and expected return approaching the expected return on the productive technology.

However, the welfare implications are very different, with a very non-monotonic relationship between the size of bank capital and consumer welfare. First, for values of n below $n^\star$, the negative effect of decreasing the amount of resources available for consumer dominates the gain due to better terms of contracts and consumer's welfare is decreasing with n. The picture changes dramatically for $n \geq n^\star$. After consumers have deposited all their endowments with bankers, additional bank capital no longer serves to attract new deposits and is used only to offer better terms of contracts. Since as in Section 6, this allows to further diminish bankruptcy risk, it increases consumer's welfare. In fact, the marginal gain in expected utility to consumer due to better terms of the contract now outweighs the marginal loss due to lower endowment. This effect prevails until, at certain level of n, denoted as $n^{\star\star}$, the marginal increases in utility due to better equilibrium contracts no longer dominate. This happens because now the probability of bankruptcy is very small, and decreasing it further is becoming more and more costly - in a way, there are certain negative economies of scale in increasing n. Comparing the two local maxima, one at $n = 0$, and the other at $n = n^{\star\star}$, for this set of parameters it turns out that consumer's welfare is actually maximized for $n = n^{\star\star}$. Hence, a planner given a possibility to allocate the endowments between consumer and banker will choose to

Figure 2: Equilibrium for different distributions of initial unit endowment



Dashed vertical line refers to the value of *n* that maximizes consumer's utility give some of the endowment to the banker even if the planner cares only about the consumer. This happens because allocating resources to banker helps the consumer to indirectly access the more productive technology that only banker can operate.

Interestingly, note that in this environment, the minimal value of banker's endowment for which all the resources are intermediated and invested in the productive technology turns out to locally minimize consumer's welfare, which seems counter-intuitive as this is the lowest value of n which achieves maximum expected output. However, due to information frictions in this economy, bankers are not able to offer contracts that would allow consumers to take advantage of this efficiency in overall production. Hence, if for some reason the economy started at this level of endowment, it would be profitable for the planner to either decrease n, shrink the banking sector and free up some resources to consumers, or shift resources from consumers to bankers, sacrificing some of the resources on consumer's side, but allow them to access far better contracts which would outweigh the loss in endowment.

8 Conclusion

This paper provided a model of financial intermediation where bank capital plays a dual role: it is directly used for investment, but it also allows banks to offer better contracts to depositors and attract deposits. As a result, it allows for a more productive allocation of resources for production in the economy. I have shown that benefits coming from a larger amount of bank capital may justify taxing consumers to provide banks with more equity. The positive impact these better capitalized banks have on the terms of the equilibrium contract may outweigh the loss associated with fewer resources at consumer's disposal.

Clearly, the model presented above is a highly stylized one and it cannot be used quantitatively. First, it only features two periods. It would be more desirable to build an infinite horizon model where the dynamic impact of shocks to output and policies such as bank recapitalization could be analyzed. Note that the dynamic model could actually strengthen some results of the model. Namely, after taxing consumers in order to recapitalize the banks, the new bank capital could be used for several periods instead of just one. In a one period model, the bank capital is socially extremely costly. In a multi-period model, one-off tax to inject capital to banks could prove desirable for far less extreme assumptions on banks relative productivity.

Second, no space is given to banks portfolio decisions. After solving the contracting problem, essentially no further role is given to banks. In particular, I assumed a fixed and stable distribution of returns on bank's assets. One could imagine a choice of technology, or the riskiness of investment by banks to be an additional feature of the model. However, this would significantly complicate the contracting problem. Perhaps a more promising extension would be to allow for analyzing shocks to output, or even potential changes to the distribution of output shock (lower mean, higher variance). This could then allow for analysis of optimality and desirability of bank recapitalization in different macroeconomic conditions.

Finally, when I analyzed the policy of reallocating the endowments, I did not consider potential contracts between consumers and bankers that would allow for this reallocation to take place as a part of decentralized equilibrium. Specifically, consumers in the model have no access to what could be referred to as equity contracts. As I have shown in Section 7, if we allow for endowments to be reallocated between agents, then for some parameter values the competitive equilibria are constrained inefficient: we can redistribute resources to make both agents strictly better off. Whether contracts that allow for such reallocation are feasible in this environment, how they look like and what role they would play remains an interesting question for future research.

Chapter 2
Bank Regulation and Financial Integration: Imbalances in the Euro Area

1 Introduction

Following the creation of the Euro area on January 1, 1999, the European economies fully integrated not only their currencies, but also their capital markets. After the integration, international capital flows between the currency area countries reached unprecedented levels. This was reflected by the current accounts balances in different Euro area countries, with several countries, most notably Germany, noting current account surpluses, whereas many other countries, Spain being the biggest, began to see current account deficits. As a whole, however, the current account balance for the Euro area remained close to zero. The capital market integration was not accompanied by unification of bank regulation. Regulation remained largely on a national level, with member states still responsible for regulating banking activities in their countries. Also, most lending to firms has still been conducted on a national level, with Spanish firms utilizing credit mostly from Spanish banks, German firms from German banks etc. Thus, most of the international capital flows between the Euro area countries went through interbank markets, throughout the whole period before the global financial crisis. Over time, these surpluses and deficits built up to significant stocks of either positive or negative foreign investment positions (IIP). In absolute terms, Germany, and specifically the German banks became the largest net lender in the Euro area and Spain, and Spanish banks, the largest net borrower.

These large flows from the European "North" to the European "South" have first been explained as flows driven by simple differences in income, allowing poor countries to accelerate their process of convergence process to the rich Euro area members (e.g. Blanchard and Giavazzi (2002)). However, in the early 2000s some new patterns emerged: along with large capital flows and resulting increase in capital stock and output, the productivity growth in borrowing countries became sluggish or even negative (Blanchard (2007)). This cast doubts on the hypothesis of simply using the capital flows to finance the most productive investment in "peripheral" countries. Instead, it raised questions about possible misallocation of resources in the capital inflow countries. However, if financial sectors were so much less efficient in the deficit countries, then why would capital flow from "efficient" uses in the surplus countries to the "inefficient" deficit countries? In this work, I suggest the reason for the direction of the flows might have been differences in how tight the financial regulation and bank lending was in different Euro area countries. Specifically, my hypothesis is that the surplus countries had relatively strict limits on borrowing, understood as how tight their collateral constraints on firms were, and the deficit countries relatively lenient ones. In order to show how these regulatory differences might have contributed to the capital flows in the Euro area, I focus on the biggest lending and borrowing economies in the currency union, respectively Germany and Spain.

In this chapter, I establish two facts. First, I bring evidence that the differences in regulations were the reasons for differences in financial intermediation and in firm financing between the two countries even before the creation of the currency union. Second, I show that these differences in financial development help explain not only the patterns of capital flows and investment positions between Germany and Spain, but also account for the observed behavior of macroeconomic variables like the increase in capital stock and output in Spain without the corresponding increase in TFP.

In my analysis, I focus on credit financing, and more specifically on bank financing to firms. The reason for this is that in both countries, bank lending has been by far the most importatnt financing channel for non-financial corporations. In 2005, according to World Bank Global Financial Development database, 32.6% of Spanish firms used banks to finance their investments and 35.8% to finance working capital. For Germany, these numbers were even higher at 45.0% and 42.2%, respectively. According to the same survey, 21.8% of all investments by firms in Spain was financed by banks, with 22.6% in Germany. Equity financing played a relatively small role, used to finance only 1.8% of investment in Spain and 9.3% in Germany. At the same time, the size of the corporate bond market for non-financial firms remained small in both economies, with the stock of outstanding corporate bonds not exceeding 5% of GDP in Germany and 2% in Spain, according to BIS data.

To prove the first point, I first look at the overall structure of bank credit to firms in Germany and Spain before the creation of the Euro area. Despite lower level of output per capita, Spain has gone through a period of financial development and deregulation in the 1990s. As a result, when the Euro area was created, Spain has already had a higher level of credit to firms relative to GDP than Germany despite the higher level of interest rates, both on the interbank market and on credit to firms.

In order to analyze these phenomena, I build a two-country, general equilibrium model with heterogeneous firms and households where firms face collateral constraints on the amount of capital they can install. Each country is populated by a continuum of households and entrepreneurs, a representative final goods producer, and a representative bank which acts as an intermediary on the capital market. Entrepreneurs produce intermediate goods in a monopolistically competitive fashion. They are subject to idiosyncratic productivity shocks, and exit shocks, which generate a need for capital reallocation between firms. Every time a firm gets hit by an exit shock, a new firm enters in its place. Critically, each firm is constrained in how much capital it can install each period, by a leverage constraint given as a multiple of firm's net worth. Since firms face constant exit probability, they cannot outgrow their way beyond the constraint. The model also features heterogeneous workers as in Aiyagari (1994), facing idiosyncratic shocks to their labor endowments. Workers are allowed to save in the bank, but are restricted from borrowing. As a result, workers' precautionary saving gives rise to an upward-sloping capital supply curve in each economy. Final goods producer combines intermediate goods from entrepreneurs and produces a final good which is then used for consumption and investment and serves as the numeraire in the model. Finally, the representative bank in each country gathers deposits from workers and entrepreneurs and lends to entrepreneurs which want to install more capital than their current net worth. Bank borrowing and lending happens inside each period after the realization of productivity shocks and is thus riskless.

I then analyze the steady-state of two closed economies, respectively calibrated to German and Spanish data for 1998. Although there are some differences in firm dynamics between two countries, namely German firms have lower death rates, it turns out that to account for differences in firm financing, it is necessary that the collateral constraint for Spanish firms be looser than for the German ones, in line with German banks being more strictly regulated than the Spanish ones. The model does well in matching other features of firm financing, including the difference in real interest rates between the two countries, lower in Germany and higher in Spain, as well as differences in capital/output ratios in the two.

I then conduct a quantitative exercize by allowing the banking sectors in the two countries to lend and borrow from each other internationally, while keeping lending to firms at the national level and subject to national collateral constraints. I then compute the steady state of this two-country integrated world economy. The model generates international investment positions in the two countries equal to about one third of these observed in the two countries within a few years after the creation of the Euro area. It also predicts changes in capital, output, TFP and credit to firms in line with those observed in the data. This suggests that the differences in regulation might be an important factor when accounting for capital flows and international investment positions observed in Europe in the early 2000s. Moreover, since the analysis is performed for a new steady state, this suggests that a significant part of the imbalances seen between Germany and Spain are not a merely transitory phenomenon, but a permanent feature of a new international equilibrium when two different financial sectors are integrated.

The rest of the chapter is organized as follows: the next section discusses the related literature. Section 3 describes the data used and established the stylyzed facts I aim to explain. Section 4 presents the model. Section 5 deals with the calibration and the selection of parameters. Section 6 presents the results, first for the closed-economy, before-integration setting, and then for the integrated economies. Section 7 concludes.

2 Literature

This work relates to a few different strings in the literature. The issue of international financial integration and capital flows has been analyzed by Mendoza, Quadrini and Rios-Rull (2009), who looked at the impact of financial development on international investment positions between the United States and the rest of the world using a two-country, general equlibrium model with financial frictions. Another general equilibrium analysis of financial integration was develped by Gourinchas and Jeanne (2006). Most other papers dealing with international financial integration focused on econometric techniques, using statistical methods rather than general equilibrium model to assess the overall economic impact of integrating capital markets - as an example, see Lane and Milesi-Feretti (2003) or Bekaert et al. (2017). This paper extends this analysis by analyzing the impact of financial regulation on capital market integration in the Euro area using a general equilibrium setting.

The impact of financial frictions on firm dynamics has been extensively analyzed in the literature, beginning with Banarjee and Duflo (2005) showing how credit constraints may give rise to capital misallocation. The theme of capital misallocation has been further developed and measured by Hsieh and Klenow (2009), who applied it to productivity discrepancy in China and India and by Mendoza (2010), who looked at the impact of financial frictions on sudden stop episodes. Arellano et al. (2012) focused more specifically on microeconomic implications of financial frictions on firm dynamics. In a more recent papers, Buera, Kaboski and Shin (2011), Moll (2014) and Midrigan and Xu (2014) have linked the behavior of country's TFP with its level of financial development.

Two interesting papers analyzing the impact of financial frictions on the behavior of macroeconomic variables in context of China were Song et al. (2011) and Bai et al. (2018). Instead of different economies, they analyze the behavior of public and private sectors in the Chinese economy, subject to different financial frictions and thus exhibiting different saving and capital allocation behavior.

In the context of Europe, Benigno and Fornaro (2014), and, specifically for Spain, Gopinath et al. (2017) use a partial equilibrium setting to analyze the impact of a country gaining access to lower interest rates from an external source and use it to explain the behavior of economies in Southern Europe - Benigno and Fornaro by reallocation from tradeable to non-tradeable sector, Gopinath et al. by a model with heterogeneous firms with size-varying leverage constraints. The paper by Gopinath et al. actually uses a somewhat similar setting to mine, focusing on the role of firm heterogeneity and financial frictions in the behavior of the Spanish economy after the creation of the Euro area. Specifically, it aims to explain the slowdown in the growth rate of TFP in the early 2000s, and the way to do this is to exploit the increase in variance in firm-level measured productivity after the decline in the interest rates. This increase is led by the leverage constraint being tighter for small (or low-net worth) firms than for large firms. As a result, small firms are slower to adjust their capital stock to the new interest rate levels than the large firms, which leads to a temporary increase in variance in measured firm-level productivity. Gopinath et al. thus focuses much more closely on the transisitonal dynamics and detailed firm-level observations. However, the analysis is only conducted in a partial equilibrium setting, as the decrease in interest rates and capital inflows are given exogenously. Thus, this work can be seen as filling the gap by implementing a similar heterogeneous-firm framework into an international general equilibrium setting, and explaining both the decrease in the interest rates, as well as the flows of capital to the Spanish economy.

3 Euro area: Germany and Spain

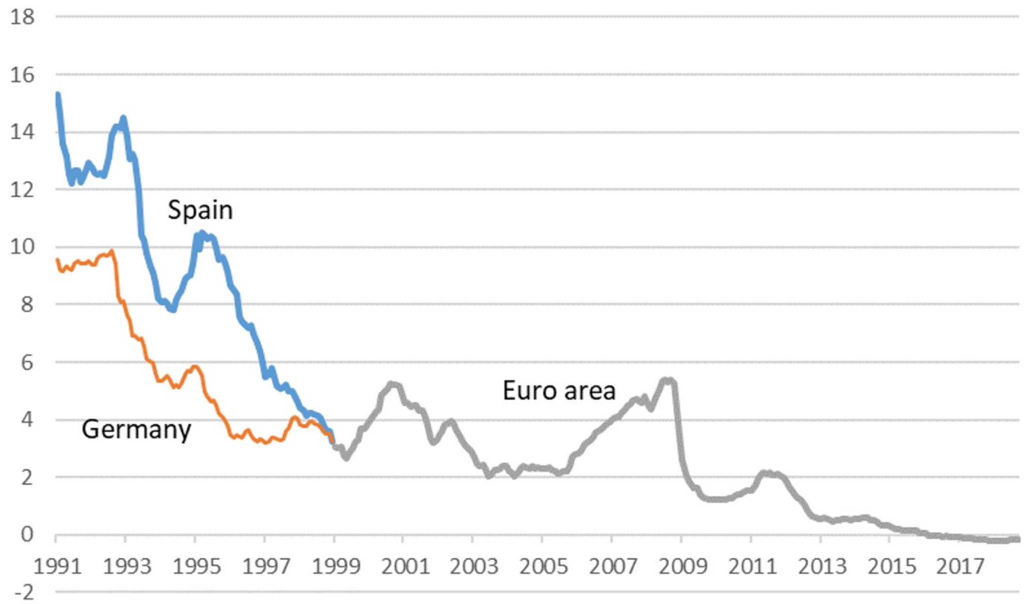
Euro area was created on January 1, 1999, first including 11 countries and the number growing ever since. The euro was first introduced as an interbank currency, with banknotes and coins replacing national currencies starting on January 1, 2001[4]. Along with monetary integration and creation of the European Central Bank came the integration of interbank credit markets: local currencies' interbank interest rates have been replaced by a single interest rate spanning the whole currency area. The convergence of nominal interest rates between countries is shown in Figure 3.

3.1 Growth accounting

After the creation of the Euro area, most European economies experienced a period of significant

[4]https://www.ecb.europa.eu/ecb/history/emu/html/index.en.html

Figure 3: Nominal Interest Rates in Germany, Spain and the Euro Area

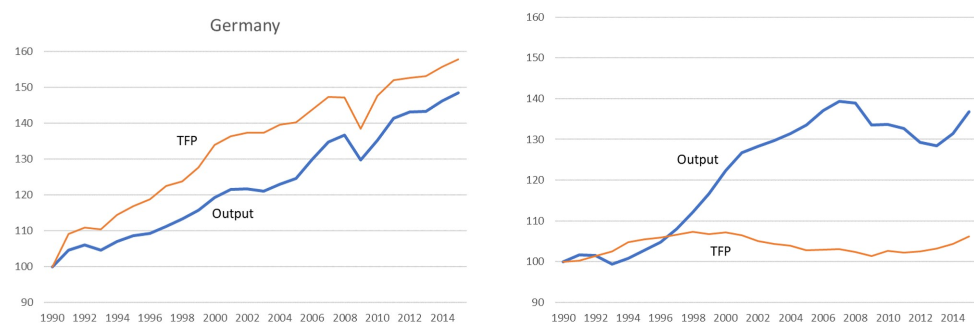


Source: ECB, Deutsche Bundesbank, Banco de Espana

economic growth in the early 2000s. This was also the case for Germany and Spain, both in absolute as well as in per working age person terms. However, the two economies behaved quite differently in terms of the composition of growth, in particular their TFP growth. I decompose the output per working age person following Kehoe (2002), using the same parameter values I use later for the model: capital share α equal 0.35 and depreciation rate $\delta = 0.08$, both standard in the literature. According to the paper, for an economy on a balanced growth path the output should grow at the same rate as measured TFP raised to the power $\frac{1}{1-\alpha}$, $A_t^{\frac{1}{1-\alpha}}$, which is the TFP series plotted on Figure 4. As shown in Figure 4, after the creation of the Euro area, Germany has been close to the balanced growth path, with both variables remaining relatively close together after the period in the 1990s when TFP grew faster than output.

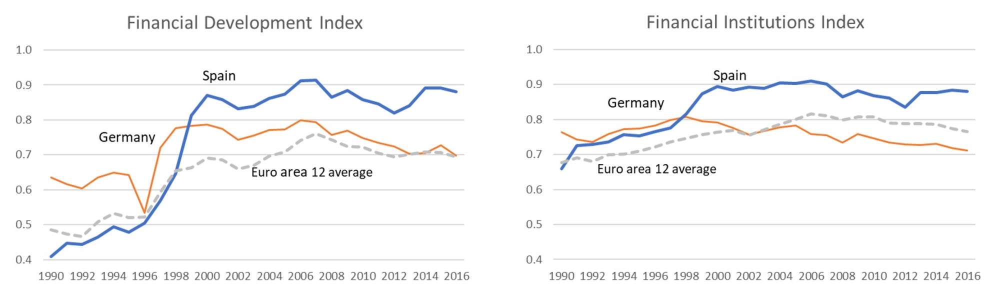
However, as shown in Figure 4, this was not the case for Spain. Even though GDP per working age person has increased significantly, the TFP has actually been decreasing over the 2000-2008 period. In terms of growth decomposition, output growth over this period was mostly driven by an increase in working hours per working age person, mostly due to large immigration, and to a lesser extent by capital accumulation. A large part of the decline in productivity has been accredited, most importantly by Gopinath et al. (2017), to an inflow of capital after the decrease in the real interest rates and a resulting increase in dispersion of productivity between firms in the manufacturing sector.

Figure 4: Output and TFP in Germany and Spain, 1990=100



Source: OECD, Eurostat. Output is in real, per-working-person terms. TFP is taken to power $\frac{1}{1-\alpha}$ for consistecy with balanced growth path.

Figure 5: IMF Financial Development Index

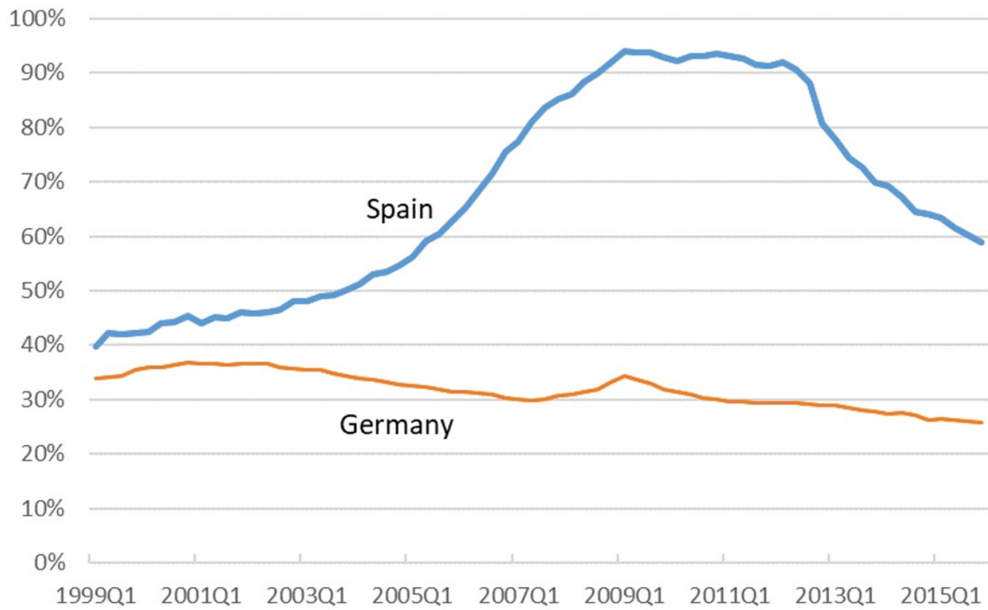


Source: Svirydzenka (2016)

3.2 Financial development and regulation

Defining the stringency of bank regulation is a multidimensional problem, and is usually done through multiple indicators (e.g. Barth et al. (2013)). Another, simple index that summarizes the level of financial development has been constructed in the IMF by Svirydzenka (2016). This Financial Development Index uses a number of indicators including credit/GDP, assets of different financial institutions like insurance companies and mutual funds, some parameters of the stock market, as well as the number of indicators on the banking system, like interest margins, lending/deposit spreads, or returns on investment and equity. The index describes the overall level of financial development, and comprises of two subindices for financial institutions and financial markets, respectively. The behavior of the Financial Development Index and the Financial Institutions Index in Spain and Germany are shown on Figure 5.

Figure 6: Bank lending to non-financial firms, share of GDP



Source: ECB, Deutsche Bundesbank, Banco de Espana

According to both the overall and to the institutions index, Spain has gone through a period of fast development of its financial sector in the late 1990s, to the point of having more developed financial institutions than Germany. According to the IMF index, Spain's average level of financial development at the moment of creation of the euro was actually higher not only than Germany's, but also higher than the average for the original 12 Euro area member countries, despite Spain still having lower GDP per capita at the time.

Another, simple and commonly used measure of bank development or is the size of the stock of credit to firms as a share of output. This has shown some interesting dynamics throughout the analyzed period. The numbers for bank credit/GDP are shown in Figure 6. Interestingly, Spain featured higher amount of firm credit/GDP than Germany even before the international flows began and despite higher interest rates, with the stock equal to 39.8% of GDP at the beginning of 1999, compared to only 33.8% in Germany at the same time. However, after the creation of the Euro area, the stock of bank lending in Spain grew significantly relative to the size of the economy, with an actual decline in Germany.

At the same time, the size of the corporate bond market for non-financial firms remained small in both economies: The nominal stock of outstanding bonds issued by non-financial corporations was only equal to around 4-5% of GDP in Germany and 1-2% in Spain throughout the whole analyzed period, according to the BIS data. Hence, we are not losing much by ommitting the numbers for corporate bonds. As a robustness check, I ran the analysis with the credit numbers including corporate bonds and the results were almost entirely unchanged.

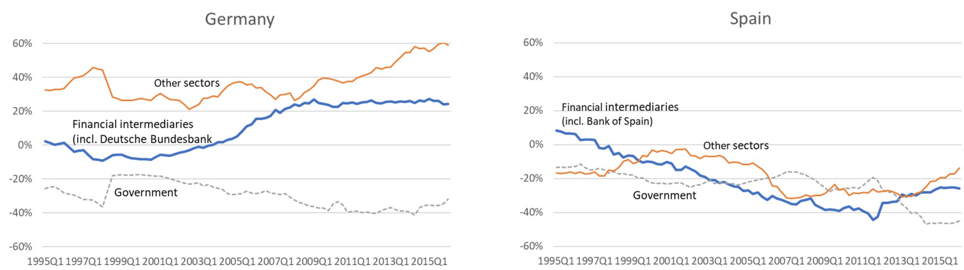
One could ask a quesition about the reasons of the relatively low financial development in Germany. Although neither the index, not the numbers on lending to firms do not explain the sources of it, it seems plausible that this lower level in Germany is not due to the worse contract enforcement or legal system. One interesting explanation could be a different structure of firm distributions in two countries, with German firms being possibly longer-lived, more stable and thus more likely to rely on self-financing rather than on bank credit. Although there is some evidence for this being true, with death rates of firms in Germany around 1 percentage point higher than in Spain (on average, around 8% against 9% in Spain), they do not suffice to quantitatively explain the different patterns in lending. In the rest of the chapter, I assume that aside from the differences in the firm distribution, it was stricter regulation and possibly more conservative lending practices of German banks that led to a lower volume of lending to firms even before the creation of the Euro area and were the main factor that accounted for the capital flows observed after financial integration.

3.3 International investment position

The increase in credit to firms by Spanish banks was to a large extent financed by Spanish banks borrowing on the international bank debt markets. Although deposits in the banking sector have grown, the loan/deposit ratio in the banking sector as a whole has increased from 0.91 at the end of 1998 to 1.09 at the end of 2006, according to the Bank of Spain data. The increase being financed by international borrowing is suggested by numbers on international investment position as a share of output shown on Figure 7. Before the creation of the Euro area, the Spanish financial sector was actually a net lender against the rest of the world. However, after the financial integration, Spanish banks began borrowing on a large scale on the international markets. This led to a deterioration of Spanish financial institutions' IIP to -32.6% of GDP by the end of 2016. It is also worth noting that borrowing by banks happened on a much larger scale than by other sectors, including household and non-financial firms.

The deterioration in Spanish banks' international investment position was almost mirrored by an improvement in IIP of German financial intermediaries. From being a slight negative borrower at

Figure 7: International Financial Position by Sector, share of GDP



Source: Deutsche Bundesbank, Banco de Espana, Eurostat

Euro area's creation, German banks became a large net lender, as their IIP improved from -5.8% of GDP to +17.1% of GDP at the end of 2006. Again, in terms of the size of the movement, changes in banks' positions were the largest among different sectors in the economy. Interestingly, the absolute sizes of Germany and Spanish banks' IIPs were quite similar, with the German net saving standing at 420 bil. euros and Spanish net borrowing at 318 bil. euros at the end of 2006.

3.4 Summary - stylized facts

To summarize my empirical findings, a few stylized facts can be established following the monetary and financial integration following the creation of the Euro:

1. Both Germany and Spain experienced economic growth, but in case of Spain the growth in output happened without a corresponding growth in productivity.
2. Spain had relatively well developed financial markets intermediation sector relative to Germany at the creation of the Euro area. Following the integration, the amount of bank lending to firms in Spain increased significantly, without a corresponding growth in Germany.
3. Large part of the increase in lending by Spanish banks was financed by borrowing on the international debt markets, as shown by the IIP data. At the same time, German banks became net lenders on these same markets.

In the next section, I develop a model used to account for these facts.

4 Model

Time is discrete. There are two countries, $i \in \{1,2\}$. In each economy, there are two kinds of heterogeneous agents, workers and entrepreneurs (intermediate good producers), with measure one per country of each, as well as a representative bank and a representative final goods producer. Workers inelastically supply work to the labor market, earn wages, and are subject to idiosyncratic, random shocks to their labor endowments as in Ayiagari (1994). In order to insure from the income risk, the workers can save in the banks, but are restricted from borrowing. Entrepreneurs run monopolistically competitive firms, employ capital and labor, are also to save or borrow from the representative bank and are subject to exit shocks and idiosyncratic shocks to productivity. The exit shock can be interpreted as receiving an irreversible shock setting their productivity indefinitely to zero, but is otherwise uncorrelated with productivity shocks, and the exit probability is identical for all level of productivity. Every time an entrepreneur receives a death shock, a new entrepreneur producing the same variety of the intermediate good enters the model with a given amount of net worth endowment to replace her. Since there is no free entry condition, this allows to keep the measure of entrepreneurs constant. At the same time, monopolistic competition and the risk of a death shock prevent entrepreneurs from growing indefinitely. Workers and entrepreneurs have the same discount factors and the same time-separable CRRA utility function of consumption. Due to the existence of idiosyncratic shocks, entrepreneurs and workers have an incentive to trade their assets on the credit market - for precautionary reasons, and in case of entrepreneurs to faster achieve the optimal capital stock. Borrowing by entrepreneurs, however, is subject to a collateral constraint, which limits the amount each entrepreneur can borrow to a certain multiple of entrepreneur's net worth. The tightness of the constraint can be interpreted as the strictness of bank regulation on credit. Analysis is confined to the steady state in each economy before integration and to the steady state of integrated economies. Before the integration, each economy can be considered as a closed one and can be analyzed separately.

4.1 Intermediate good producers

In economy i, there is a continuum of intermediate good producers of measure one. They are monopolistically competitive, with each entrepreneur producing their own variety of an intermediate good. The entrepreneur's state is given by their productivity z and by their net worth a. Productivity has two components, a permanent z_P and a temporary one z_T. Each period, entrepreneur hires labor and capital for production, which generates profits π, and they might deposit some of their net worth in a bank at the interest rate r. In order to simplify the analysis, I adopt the assumption used, among others, by Buera, Kaboski and Shin (2011) or by Moll (2014), that exogenous shocks to productivity are known to the entrepreneurs when they makes their decisions about hiring capital and labor. The choice of capital is subject to a collateral constraint, which may vary between different economies. After production and payment to workers and capital owners, the entrepreneur chooses between consumption and assets (net worth) she allocates for the next period. Moreover, at the beginning of each period, the entrepreneur also faces a risk of a death shock, coming with probability ζ. If the entrepreneur receives this shock, she receives utility value $U(a)$ equal to the utility of a constant stream of consumption with present value equal to her net worth. Finally, after opening of the international lending and borrowing market, I assume the intermediate goods are non-tradable. Since intermediate good producers all face identical problems and the measure of them is constant over time, I drop the subscripts denoting the particular variety the firm produces.

Entrepreneur's Bellman equation is given by:

$$V(a,z) = \zeta U(a) + (1-\zeta)\{\max_{c,k,l,a'} u(c) + \beta \mathbb{E}_{z'} V(a',z')\}$$

subject to:

$$c + a' \quad = \quad \pi(k,l,a,z) + (1+r)a$$

where $U(a)$ is the utility the entrerpreneur obtains if she receives a death shock, and π is the profit earned by entrepreneur's firm.

4.1.1 Intra-period problem

Within the period, conditional on not receiving the death shock and after learning about the value of her temporary productivity component, the entrepreneur hires capital k and labor l in order to maximize profits. The price of labor is wage, denoted as w. The rental price for capital is equal to the interest rate r. Moreover, during production, capital depreciates at rate δ. Since entrepreneurs are monopolistically competitive, they also choose the price of their intermediate goods' variety p, subject to their demand function. The demand function for a variety comes from the solution of the final good producer's problem (see below), and is known to the entrepreneur. The entrepreneur's problem within the period is given by:

$$\pi = \max_{\{y,k,l,p\}} \{py - wl - (r+\delta)k\}$$

subject to the production function (PF), the demand function (DF), and the collateral constraint

(CC):

$$\begin{aligned}(PF)\quad y &= zf(k,l)\\(DF)\quad y &= \frac{Y}{P}\cdot\left(\frac{p}{P}\right)^{-\gamma}\\(CC)\quad k &\leq \bar{k}(a,\lambda,w,r)\end{aligned}$$

Firms are monopolistically competitive as in Dixit-Stiglitz model, with the elasticity of demand equal to γ. $Y = \left[\int y(i)^{\frac{\gamma-1}{\gamma}} di\right]^{\frac{\gamma}{\gamma-1}}$ is the aggregate output in the economy, and $P = \left[\int p(i)^{1-\gamma} di\right]^{\frac{1}{1-\gamma}}$ is the aggregate price level. Both are implied by the aggregate state of the economy, and are constant in the steady state, but will differ between economies and before and after financial integration. This leads to a standard markup pricing, where the price is a markup over firm's marginal cost, $p = \frac{\gamma}{\gamma-1}MC$. However, the collateral constraint limits the amount of capital entrepreneurs can hire within the period and prevents them from attaining socially optimal allocations. The constraint is obtained as follows: for any borrowing, which is defined as the excess of capital installed over firm's own assets, $k-a$, the amount that the entrepreneur has to repay on her loan is limited to a multiple of firm's net worth:

$$(1+r+\delta)(k-a) \leq \lambda a$$

This leads to a constraint on the amount of capital the firm can install being a multiple of firm's assets:

$$\frac{k}{a} \leq \frac{1+r+\delta+\lambda}{1+r+\delta}$$

with $\lambda \geq 0$, where $\lambda = 0$ corresponds to a complete shutdown of capital rental market and $\lambda \to +\infty$ corresponds to perfect capital markets.

Note that with this form of the constraint, the amount of capital the firm can hire depends not only on the value of collateral parameter λ, but also on the level of interest rates in the economy, with interest faced by the firm equal to $r+\delta$. Thus, even for two economies with identical λ's, the maximum leverage used by firms might differ if economies for some reason exhibit different interest rates, constraints being looser if interest rates are low.

Finally, the temporary component of productivity z_T, evolves according to an AR(1) process in logarithms with autocorrelation parameter ρ_z and a normally distributed error term with zero mean and standard deviation σ_z.

$$\log z_{T,t+1} = (1-\rho)\bar{z_T} + \rho_z \log z_{T,t} + \varepsilon_t^z$$

4.1.2 Exit and entry

If the firm receives the death shock, it receives utility $U(a)$, where U is the utility of a constant stream of consumption with present value equal to a, i.e. equal to the utility from a constant stream of consumption equal to $\frac{a}{r}$. This utility is given by:

$$U(a) = \frac{1}{(1-\beta)} u\left(\frac{a}{r}\right)$$

For every firm that receives the death shock, a new firm producing the same variety is born. The new entrant receives an initial endowment of assets a_0, and a level of productivity z, given by the product of a draw from the permanent productivity distribution $F(z_P)$ and a draw from the invariant distribution of temporary productivity distribution $G(z_T)$. This ensures that the distribution of productivity parameters in the economy remains constant over time and essentially turns off the aggregate risk. After birth, the firm immediately enters the labor and capital rental markets. Hence, the measure of firms in the economy remains constant over time.

4.2 Final good producer

The economy features a representative, competitive final good producer. The producer takes the varieties produced by intermediate goods producers and combines them into a final consumption good using a CES production function:

$$Y = \left[\int_0^1 y(i)^{\frac{\gamma-1}{\gamma}} di\right]^{\frac{\gamma}{\gamma-1}}$$

where γ is the elasticity of substitution between different varieties. The price of the final good is normalized to one. Final good producer solves the problem of minimizing costs of production of a given amount of the final good:

$$\min_{y(i)} \int_0^1 y(i)p(i)di$$

subject to the output of the final good being $Y = \left[\int_0^1 y(i)^{\frac{\gamma-1}{\gamma}} di\right]^{\frac{\gamma}{\gamma-1}}$. This specification of the problem gives rise to the standard Dixit-Stiglitz (1977) algebra for the demand functions for individual varieties, with the demand function for individual variety given by:

$$y(i) = \frac{Y}{P} \cdot \left(\frac{p(i)}{P} \right)^{-\gamma}$$

where $P = \left[\int p(i)^{1-\gamma} di \right]^{\frac{1}{1-\gamma}}$ is the aggregate price level.

However, due to idiosyncratic shocks received by the intermediate goods producers and due to imperfect financial markets in the economy, the joint distribution of assets and productivity can only be obtained numerically. As a result, the aggregate output in the economy, Y, can also only be calculated through numerical methods. Y is used as the measure of GDP in the economy. For economies with different parameters, and because the final good is the numeraire, the price index for the intermediate goods P might also differ between countries.

It is important to note that the final good is the numeraire in the model. It is also the good in which lending and borrowing take place, and once the two economies integrate, it is also the good which is traded between countries.

4.3 Workers

Workers are infinitely lived and similar to the households described by Ayiagari (1994). Each period, workers receive a stochastic endowment of labor, l, which they then supply inelastically to the labor market which pays wage w per unit of labor. In addition, workers can also save, but not borrow, their assets n in banks. The banks pay a rental rate r. Labor endowment evolves stochastically following an AR(1) process in logs:

$$\log l_{t+1} = (1-\rho)\bar{l} + \rho_l \log l_t + \varepsilon_t^l$$

The mean of the labor endowment is normalized to ensure the aggregate labor supply equals one in every period.

Worker's Bellman equation is given by:

$$W(n,l;w,r) = \max_{c,n'} \{u(c) + \beta \mathbb{E}_{l'} V(n',l';w',r')\}$$

subject to:

$$\begin{aligned} (1+r)n + wl &= c + n' \\ n' &\geq 0 \end{aligned}$$

Hence, given prices and the stochastic process for labor endowments, there exists a steady-state joint distribution of households over their net worth and labor endowments. Since workers' net worth is constrained to be positive, they will be net supplier of savings to the banking sector. Moreover, since the primary role of workers' savings in the model is precautionary saving, the supply curve of capital by households is going to be an upward-sloping function of the interest rate r, and is going to be non-degenerate and positive for different values of r.

4.4 Banks

Banks act as intermediaries on the capital market. Each period, they collect deposits from domestic households and firms, and grant loans to domestic firms. Banks are assumed to be competitive, and make zero profits. Thus, the interest rate on deposits is equal to r, and the interest rate on loans equals $r+\delta$, since banks have to be compensated for the depreciation of capital lent to the entrepreneurs. The balance sheet of the representative bank in country i in the closed economy version of the model is given by:

$$\int n d\Gamma_i(n, l_s) + \int \mathbf{1}_{a \geq k}(a-k) d\Phi_i(a,z) = \int \mathbf{1}_{k>a}(k-a) d\Phi_i(a,z)$$

The left hand side is the sum of deposits by households and by firms, and the right hand side is total bank lending to firms - note that the firm is considered a depositor if its net worth is higher than the capital stock it installs, i.e. $k < a$, and a borrower if the opposite is true, i.e. $k > a$.

After the financial integration, I assume that banks in different countries can also lend and borrow from each other. However, the deposits and loans to entrepreneurs are still kept on a national level and are subject to local collateral constraints. This mimics the patterns of financial integration following the creation of the euro, with widespread interbank lending, but without much cross-border loans or deposits between firms, households and banks. Since banks are competitive in each country, interest rates are still going to be equalized between the two countries, even though firms and households in each cannot directly access banks abroad. Let the lending made by the representative bank in country i to banks abroad be denoted as IIP_i - it is going to correspond to banking sector's net international investment position. Following the integration, the balance sheet of the representative bank in country i becomes:

$$\int nd\Gamma_i(n,l_s) + \int \mathbf{1}_{a\geq k}(a-k)d\Phi_i(a,z) = \int \mathbf{1}_{k>a}(k-a)d\Phi_i(a,z) + IIP_i$$

Finally, the sum of international borrowing and lending must equal zero:

$$\sum_i IIP_i = 0$$

That is, for a two-country model, first country's banks' borrowing must be second country's banks' lending.

4.5 Equilibrium in a closed economy

We can now bring all the elements together and define the competitive equilibrium in a closed economy.

Definition: Intermediate goods' producer's individual state is given by $s(i) = (a(i), z(i))$. Individual household's state is given by $t(j) = (n(j), l_s(j))$. Aggregate state S is given by distributions of firms $\Phi(a,z)$ and households $\Gamma(n,l_s)$. Stationary competitive equilibrium in this economy is given by:

- prices $(r, w, p(j)_{i=0}^{1})$
- agents' value functions $(V(S,s), W(S,t))$ and policy functions for firms $(d(S,s), a'(S,s), k(S,s), l(S,s))$ and households $(c(S,t), n'(S,t))$
- distribution of agents over states $\Phi(a,z)$ - for entrepreneurs, and $\Gamma(n,l_s)$ - for workers

such that:

1. Given her individual state, prices and the law of motion of aggregate state, value and policy functions of each worker solve the worker's problem
2. Given her individual state, prices (r,w), her demand function and the law of motion of aggregate state, value and policy functions of each entrepreneurs solve the entrepreneur's problem

3. Given prices, the final good producer solves her cost minimization problem

4. Labor market clears and banking sector's balance sheet equation holds:

$$\begin{aligned}\int (l(a,z)d\Phi(a,z) &= \int l_s d\Gamma(n,l_s)\\ \int nd\Gamma_i(n,l_s)+\int \mathbf{1}_{a\geq k}(a-k)d\Phi_i(a,z) &= \int \mathbf{1}_{k>a}(k-a)d\Phi_i(a,z)\end{aligned}$$

5. Aggregate state given by the distribution of firms and households evolves according to:

$$\begin{aligned}\Phi(a',z') &= F(\Phi(a,z))\\ \Gamma(n',l_s') &= G(\Gamma(n,l_s))\end{aligned}$$

6. Economy remains in the stationary equilibrium:

$$\begin{aligned}F(\Phi(a,z)) &= \Phi(a,z)\\ G(\Gamma(n,l_s)) &= \Gamma(n,l_s)\end{aligned}$$

Note that on the capital market, the firms are the only ones on the demand side since there is no borrowing by households. However, on the capital supply side, some of the capital consists of capital supplied by firms and some of capital supplied by households. The sum of differences between capital installed by firms and these firms' assets is then used as a measure of the amount of credit in the economy. This includes two components: savings by households, as well as assets being reallocated between firms - for example, between firms which received an unfavorable productivity shock to ones who received a good one.

4.6 Economic integration

I define the economic or financial integration as two economies beginning to share one, common capital market. Since there is no aggregate risk, this implies that the price of capital on the rental market is now the same everywhere and equals r. Moreover, individual firms are still subject to the same death rates and collateral constraints - this is equivalent to firms still being subject to local regulations and borrowing from their domestic banking sectors. Labor markets and markets for individual varieties of intermediate goods also remain closed. The second decision shuts down the complications related to an increase in the number of available varieties in each country.

I allow for two integrating economies to be different in size - let the size of one economy be given by N_1, and the other by N_2. The relative size of both economies only plays a role in the market clearing condition, but does not affect the number of intermediate good varieties produced in each economy - this is set equal to one in each.

Overall, there are three parameters that can be different in the two economies:

- Average productivity of intermediate goods' producers
- Death rate of firms
- Collateral constraint parameters

Also, each economy remains with a separate distribution of intermediate goods prices $p_i(j)_{i\in\{1,2\}}$ and wages w_i. The equilibrium definition in the (integrated) global economy remains very similar to two separate economies, except there is not only one interest rate r, which comes from a market clearing condition common for both countries. This can be summarized by the balance sheet equaltion for the representative bank in country i:

$$\int nd\Gamma_i(n,l_s) + \int \mathbf{1}_{a\geq k}(a-k)d\Phi_i(a,z) = \int \mathbf{1}_{k>a}(k-a)d\Phi_i(a,z) + IIP_i$$

with the additional condition that the international investment position of the integrated two-country economy equals zero:

$$\sum_i N_i \cdot IIP_i = 0$$

Since international borrowing and lending is the only part where the relative size of the two countries matters, this is the only equaltion where these relative sizes enter.

5 Calibration

In the next step, the model is calibrated to match the relevant moments in the data. One period in the model is set to equal one year in the data. Table 1 shows the values of these parameters of the model. For specific funcional forms, I choose the standard CRRA utility with risk aversion parameter σ and discount factor β, both identical for both households and entrepreneurs. Production function of intermediate good producers is Cobb-Douglas with capital share parameter α. Elasticity of demand for individual varieties produced by intermediate good producers is given by γ. Parameters $(\alpha, \beta, \delta, \sigma, \gamma)$ are assumed to take values standard in the literature. Finally, initial entrants are assumed to start with assets equal $a_0 = 0.1$.

For the firm's productivity processes, I assume the permanent component to be distributed Pareto with the tail parameter η equal 3. Due to monopolistic competition and indivual firms thus behaving as if they faced decreasing returns to scale, this translates to employment distribution being (in the undistorted case) close to one observed empirically, with tails significantly thicker than those implied by the distribution of permanent productivity components. The transitory component is assumed to follow an AR(1) process in logs, with parameters ρ_z and σ_z identical to those estimated by Gopinath et al. (2017).

Household's labor endowment follows an AR(1) process in logs, with corrleation coefficient ρ_l standard deviation σ_l. Parameters for the household process have been set at $\rho_l = 0.9$ and $\sigma_l = 0.2$, consistent with Guvenen (2009). Standard deviation is set to generate the ratio between the 90th and the 10th percentile of labor income of around 3.5, similar to one observed in the data for Germany and Spain in the period. The mean of the labor endowment process is adjusted to equal one in original metric - this sets aggregate labor supply equal to one in each economy.

There are three parameters in the model that I allow to be country-specific: firm death rate ζ, average firm productivity $\bar{z}$, and the collateral constraint λ. Of these, I take the death rate straight from the data reported by Eurostat, with ζ=0.08 in Germany and $\zeta = 0.09$ in Spain. For productivity and collateral paremters, I have to solve the model in order to compute the targeted moments. These moments are the volume of firm credit relative to output and the relative ratio of wages in two countries, both targeted at their 1998 levels. The values of country-specific parameters are shown in Table 2. The values of the moments targeted by these parameters are shown in Table 3. Overall, it appears that after calibration, the model captures the financing patterns of both economies reasonably well.

Table 3: Calibration : Parameter values

Var	Value	Description	Comments
σ	2.0	Risk aversion	
β	0.95	Time preference	
α	0.35	Capital share	
δ	0.08	Depreciation rate	
γ	3.0	Demand elasticity for monopolistically competitive producers	
a_0	0.1	Entrant's initial assets	Scaled by country's productivity
η	3.0	Tail parameter of the distribution of permanent component of z	
ρ_z	0.6	Persistance of temp. productivity	Gopinath et al. (2017)
σ_z	0.1	Std. dev. of temp. productivity	Gopinath et al. (2017)
ρ_l	0.9	Persistance of labor endowment	
σ_l	0.2	Std. dev. of labor endowment	90/10 labor income ratio of 3.5

Table 4: Country-specific parameters

	Value		
Parameter	DE	ES	Description
$\bar{z}$	1.60	1.00	Average firm productivity
λ	0.68	1.19	Collateral constraint
ζ	0.08	0.09	Death rate of firms

Taking the country-specific parameters jointly, we might characterize the two economies in the following way: Germany has a more stable corporate sector, as indicated by a lower death rate of firms. The firms are also significantly more productive. At the same time, the bank lending standards in Germany are far more restrictive than in Spain, likely due to tighter regulation. Together, the tighter collateral constraint and lower death probability mean that firms in Germany rely on self-financing more than firms in Spain - they have less ability to leverage up significantly, but there is also less need to reallocate capital from exiting to entering firms, simply because Germany has fewer of both.

Table 5: Targeted moments

	Model		Data (1998)	
Moment	DE	ES	DE	ES
Avg real wage ratio	1.28		1.28	
Firm credit, % of GDP	34.7	39.5	33.8	39.8

Table 6: Non-targeted moments - before integration

	Model		Data (1998)	
Moment	Germany	Spain	Germany	Spain
Real interest rates	2.0%	2.5%	1.8%	2.5%
Relative K/Y ratio	1.19		1.13	

6 Results

6.1 Pre-integration

To check the validity of the model and the chosen parameters, I first I calculate some additional, untargeted moments generated by the model for the two economies before the financial integration. The results for two untargeted moments are presented in Table 4. Overall, the model does well in terms of matching the moments that characterize the credit markets and the aggregate amount of capital used in both economies. For the interest rates, the really crucial part is the difference between rates in the two countries rather than the absolute level, since the latter is generally determined by the choice of the discount rate β. As it is assumed to be identical between the two economies, the difference between the real interest rates in the two economies is determined by country-specific parameters, most importantly collateral constraints. In addition to matching the targeted size of credit to GDP, the model successfully replicates the non-targeted difference in real interest rates between Germany and Spain - the model generates a difference of 0.56 percentage points, versus 0.70 percentage points in 1998 observed in the data. This suggests the validity of the chosen form of financial constraints differing between the two countries.

Tighter collateral constraints and lower firm death rates in Germany also result in German firms accumulating more capital relative to their output. I compare the relative capital/output ratios in two countries. Admittedly, the model does not replicate the absolute values of capital/output stocks in both economies - most likely due to its focus on the corporate sector and not modelling the housing sector, or other forms of capital. Still, according to the model, German firms' capital/output ratio is about 19% higher than in Spain. This actually overstates the actual difference measured in the data, where estimated capital/output ratio in 1998 in Germany has been about 13% higher than in Spain.

6.2 After integration

After calibrating and solving the model for two economies separately, I then solve the model for an integrated equilibrium described in Section 4.5. To match the relative size of the two economies

Table 7: Post-integration

Moment	Model		Data (2006)	
	DE	ES	DE	ES
Banks IIP, % of GDP	+4.1%	-9.2%	+12.2%	-30.7%
% change in K/Y ratio	-0.3%	+0.6%	-3.4%	+4.6%
% change in capital stock	-0.3%	+0.9%		
% change in output	-0.1%	+0.3%		
% change in measured TFP	0.0%	-0.1%		

I set Germany's size to be twice that of Spain's, in line with their working-age populations in late 1990s. After integration, the new steady state features interest rate slightly lower than the population-weighted average of the two closed economies, with the new real interest rate equal to 2.14%. The moments in the integrated, two-country general equilibrium are presented in Table 5.

The model generates about one third of the changes in international financial positions observed over the period of 1998-2006. Germany becomes a net lender and Spain becomes a net borrower. In sectoral terms, this result is mostly driven by changes in savings by households, which significantly decline in Spain in reaction to lower interest rates and correspondingly increase in Germany. Firms' net worth in both countries does not change significantly, actually with a small increase in Spain and a small decrease in Germany. The model also generates part of the increase in capital/output ratio observed in Spain through the analyzed period.

On other variables, the impact is relatively small, but it matches all the qualitative characteristics of the phenomena observed after the creation of the Euro area. Capital stock increases in Spain and decreases in Germany, Spain observes an increase in output of about 0.6%, with the measured TFP actually decreasing. This happens since due to lower steady state interest rates, firms accumulate more capital which in the absence of changes in the production technology translates to a lower measured productivity on the economy level. Still, an increase in output due to capital accumulation more than outweighs the negative change in TFP.

While the results on chagnes in output and measured TFP might appear small, it is important to remember that the analysis here addresses the steady state, and not the transition dynamics. As suggested by Gopinath et al. (2017), most of the decline in the measured TFP in Spain after the creation of the Euro area was due to transition dynamics and smaller firms taking longer to adjust to a new equilibrium. My analysis suggests that even this effect aside, the TFP in Spain is likely to be lower in the long-run after the economic integration relative to its closed-economy counterfactual.

Moreover, following the integration I keep the collateral constraints constant in the two countries. As a result, credit to firms moves in directions observed by the data, but it does not change significantly. If it the collateral constraints were allowed to change to match the actual volume of lending observed in the data, the impact on other variables would have been significantly higher.

Moreover, the results of the model suggest that a relatively large part of significant net international investment position stocks following the integration are not a transitory phenomenon but rather a part of new long-run equlibrium. In the two-country equilibrium, the capital accumulated by households is then lent by banks in highly regulated economies to banks in low-regulated ones, and then lent to firms in those economies to firms. This leads to changes in capital stock, output and productivity going in same directions as those observed in the data.

7 Conclusion

The aim of this work is to help explain the impact the different financial sector regulations in the Euro area economies had on the patterns of financial flows, credit to firms and other macroeconomic variables. The first contribution is providing evidence of relatively lower degree of regulation and conservatism of banks in deficit countries, most notably Spain, relative to those in surplus countries like Germany. These differences in regulations can account for the differences between the firm financing patterns observed in the data before the creation of the Euro area and integration of capital markets. Second, I show that these differences in regulation help explain the observed patterns in international capital flows, with Germany becoming a surplus country and Spain becoming a deficit one, also accounting for the patterns observed in their output, capital stocks and TFP. My results suggest that as long as regulatory differences exist, the significant absolute international financial positions between Euro area countries are likely to persist.

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Appendix

This appendix includes proofs related to the features of the optimal contract described in Chapter 1.

Lemma: Any solution $S^{\star}, g^{\star}(R), C^{\star}$ to Problem 3.1. has the property that $S^{\star} = \{R : R < \tilde{R}\}$ for some $\tilde{R}$.

Proof: For this part, it will be easier to deal with a dual problem of maximizing banker's expected payoff subject to a given depositor's utility level. By duality, the two problems are equivalent. The dual problem is given by:

Problem A.1:

$$\max_{S, g(R), C} \left\{ \int_S \{\mu R - g(R)\} dF(R) + \int_{S'} \{R - C\} dF(R) \right\}$$

subject to:

$$\begin{aligned} \int_S u(s + g(R)) dF(R) + \int_{S'} u(s + C) dF(R) \geq K & \qquad \text{(depositor's utility)} \\ \mu R - g(R) > R - C \forall R \in S & \qquad \text{(incentive compatibility)} \\ C > 0, C \leq R \forall R \in S', 0 \leq g(R) \leq \mu R \forall R \in S & \qquad \text{(nonnegativity)} \end{aligned}$$

The proof follows by contradiction. I show that there exists an alternative contracts which delivers the same utility to the depositor but strictly increases payoffs to the banker. Roughly speaking, for any verification region of R that has a non-verification region to its left (i.e. verification for lower values of R), I can shift the verification region to the left and keep the distribution of payments to depositor the same as before. By saving on bankruptcy costs, which are strictly increasing in R, I thus make the banker strictly better off.

Formally, suppose that in the solution to the problem A.1 there exists an interval $B = (R_3, R_4)$ for which verification takes place. Let $\pi_B = \int_B dF(R)$ be the probability that R falls into this interval. To obtain a contradiction, take an interval $A = (R_1, R_2)$ such that A features no verification, $R_1 < R_2 < R_3 < R_3$ and $\pi_A = \pi_B$. Interval A is thus to the left of B. I will show that shifting the bankruptcy region from B to A while holding the distribution of payoffs for the depositor constant leads to strictly higher expected profit for the banker due to lower verification costs. The alternative contract has the following form: on B, we keep the constant payment to the depositor equal to C. On A, we will construct payment to the depositor of $\hat{g}(R)$ which has the same distribution on A as the payment specified in the previous contract $g(R)$ had on B. Since $\pi_A = \pi_B$, this leads to the situation when depositor's consumption, seen as a random variable in itself, has the exact same distribution as under the previous contract. Namely, we will construct $\hat{g}(R)$ to be $\hat{g}(R) \equiv \hat{X}$ with:

$$\text{Prob}(\hat{X} \leq x | R \in A) = \text{Prob}(X \leq x | R \in B) \, \forall c \in (\inf_{R \in B} g(R), \sup_{R \in B} g(R))$$

More intuitively, for any level of consumption specified on B by $g(R)$, we associate the same level of consumption on A with the same probability. We can then repeat the process for all other values taken by $g(R)$ on B. Since the only source of variation in consumer's consumption is due to the possible verification in the contract, this leads to a situation when consumption under the new contract, seen as a random variable, has the exact same cumulative distribution function as before, the only difference being that it now takes different values for realizations of R that lie within intervals A and B. As regards feasibility, since $g(R)$ was feasible on B, then by incentive compatibility $g(R) < C$. Since C was feasible on A as there was no verification in that interval under the previous contract, and $\hat{g}(R)$ by construction takes the same values as $g(R)$ did, we have that is feasible on A. Similarly, since paying C to depositor was feasible on A, it is also feasible on B since B includes larger values of R than A. By the same token, since C was feasible on A, it is also clearly incentive compatible for the banker on B, as there are more resources available for every $R \in B$ as compared to values of R on A.

I've shown that the new contract is feasible, incentive compatible for the banker and that the consumer is indifferent between the two contract. It remains to show that it delivers strictly larger payment to the banker. Since payments on sets other than A and B are identical under both plans, we will only consider expected payments on these two sets. Under the old and the new contracts, the payments are:

$$\begin{aligned} P_{old} &= \int_A \{R - r\} dF(R) + \int_B \{\mu R - g(R)\} dF(R) \\ P_{new} &= \int_A \{\mu R - \hat{g}(R)\} dF(R) + \int_B \{R - r\} dF(R) \end{aligned}$$

and the difference between the two is:

$$
\begin{aligned}
B_{new} - B_{old} &= \int_B \{R - r - \mu R + g(R)\} dF(R) - \int_A \{R - r - \mu R + \hat{g}(R)\} dF(R) = \\
&= (1-\mu)[\int_B R dF(R) - \int_A R dF(R)] - \\
&\quad -r[\int_B dF(R) - \int_A dF(R)] + [\int_B g(R) dF(R) - \int_A \hat{g}(R) dF(R)] = \\
&= (1-\mu)[\int_B R dF(R) - \int_A R dF(R)] > 0
\end{aligned}
$$

The last line follows since by construction, we have $\int_B dF(R) = \int_A dF(R)$. Moreover, we have also constructed $\hat{g}(R)$ so that $\int_B g(R)dF(R) = \int_A \hat{g}(R)dF(R)$. Hence, the only remaining term is the difference between verification costs, which is positive since $\int_B dF(R) = \int_A dF(R)$ and for every R in A, every R in B is larger and hence expected value of R on B is strictly larger than the expected value on A. Since $0 < \mu < 1$, the inequality follows. Consequently, I have established that the proposed alternative contract is feasible and incentive-compatible, and yet delivers strictly larger expected profit to the banker. As a result, the original contract could not have been optimal. *Q.E.D.*

We can now prove the theorem further characterizing the optimal contract.

Theorem: Any solution to problem has the following properties: $g^\star(R) = \mu AR$ for $R \in S$. The cutoff level $\tilde{R}$ is determined as $\tilde{R} = \frac{C}{A}$.

Proof: The theorem states that if there is verification, then the depositor receives all the output net of verification costs and the banker receives nothing. The second part of the theorem states that given C, the banker only submits to verification if it is not feasible for her to pay the promised amount C.

The first part is again a proof by contradiction. Suppose that in the optimal contract there exists an interval $P = (R_1, R_2)$ for which there is verification (by lemma, this implies that $(R_2 \leq \tilde{R})$ and the payoff to the banker is strictly positive. I propose an alternative contract where the payoff to the banker is zero on this interval. Instead, the banker receives slightly larger payoff in states where there is no verification so that the ex ante expected payoff to the banker is held constant. I also keep the verification region constant. I will then show that this contract is feasible and it delivers strictly larger expected utility to the consumer, exploiting consumer's risk aversion.

First, define the change (a decrease) in the transfer paid to depositors if there is no verification (on set S') by:

$$a = \frac{\int_P [\mu AR - g(R)] dF(R)}{\int_{S'} dF(R)}$$

Since the remainder is paid to the banker, the expected payment to the banker remains the same by construction. This change is feasible for a (equivalently, P) small enough, since the previous contract featured payment C to consumer on S and a non-negative payment $R-C$ to banker. New payments are given by $C-a$ to the consumer and by $R-C+a$ to the banker. If a is small enough, this change is feasible, and we can make sure this holds by suitably adjusting P.

It remains to show that the new contract is strictly preferred by the consumer. I will do this by showing that the distribution of depositor's consumption associated with old contract is a mean-preserving spread of the distribution imposed by the new contract.

First, it is clear that since realizations of R for which there is verification are the same for both contracts, and the mean payment to the banker is the same in both contracts, then the mean payment (and consumption) to the depositor is also the same. However, as I will now show, the distribution is now more "squeezed", or less spread. Let us compare cumulative distribution functions of depositor's consumption under both contracts. First, note that for a small enough a, the following inequality holds:

$$g(R) < C - a \forall R \in S$$

This is true, since by IC, we have, for $R \in S$:

$$\begin{aligned} \mu R - g(R) &> R - C \\ g(R) &< C - (1-\mu)R \end{aligned}$$

Hence, if $a < (1-\mu)R$, then the inequality holds. If a turns out to be too large, then we can always make it smaller by suitably adjusting the size of interval P.

By incentive compatibility constraint, $g(R) < C$ for every $R \in S$. Define a random variable $\hat{X}$ which gives a size of consumption for the consumer as a function of R.

$$\hat{X} = \begin{cases} g(R) & \text{if there is verification} \\ C & \text{if there is no verification} \end{cases}$$

The CDF of $\hat{X}_{old}$ is then

$$F_{old}(X) = \begin{cases} \int 1_{g(R)\leq X} dF(R) & \text{for } X < C \\ 1 & \text{for } X \geq C \end{cases}$$

And the CDF of $\hat{X}_{new}$ is:

$$F_{new}(c) = \begin{cases} \int 1_{\hat{g}(R)\leq X} dF(R) & \text{for } X < C - a \\ 1 & \text{for } X \geq C - a \end{cases}$$

Since under the new contract $\hat{g}(R) > g(R)$ for $R \in P$, as all the payoff previously going to the banker now goes to the customer, we have

$$F_{new}(X) - F_{old}(X) \begin{cases} \leq 0 & \text{for } X < C - a \\ > 0 & \text{for } C - a \leq X < r \\ = 0 & \text{for } X \geq C \end{cases}$$

Since $\hat{X}_{old}$ and $\hat{X}_{new}$ by construction have the same mean, this implies that $\hat{X}_{old}$ is a mean-preserving spread of $\hat{X}_{new}$. As such, given that u is assumed to be strictly concave[5] and strictly increasing, this implies

$$\mathbb{E}u(\hat{X}_{new}) > \mathbb{E}u(\hat{X}_{old})$$

that is, the new contract delivers strictly higher expected utility to the depositor. This establishes the contradiction to the initial claim of the old contract being optimal.

We can now prove the second part of the theorem. Again, suppose that the cutoff $\tilde{R}$ was such that $\tilde{R}A > C$. In this case, there exists an $\hat{R} < \tilde{R}$ such that $RA > C \ \forall R > \hat{R}$, i.e. it is still feasible to pay C to consumers. Consider an alternative contract that has no bankruptcy for $R \geq \hat{R}$. Since in the previous part of the theorem I've already shown that in the previous contract the payoff to banker must have been zero on $(\hat{R}, \tilde{R})$ and it is now strictly positive on this interval, the bankers are now strictly better off. Second, since verification was supposed to be optimal for the banker, it must have

[5]This is not affected by presence of storage, since if $u(x)$ is strictly concave in x, then $u(s+x)$ is also strictly concave in x.

been that:

$$g(R) < C \forall R \in (\hat{R}, \tilde{R})$$

Hence, avoiding bankruptcy on this interval increases consumer's consumption for all point on the interval. As a result, both agents are strictly better off, which contradicts the assumption of the previous verification region being optimal. Loosely speaking, having bankruptcy for realizations of R that still allow for payments of C to the consumer means that both sides "leave money on the table" by contracting on a bankruptcy when it is not necessary. By removing this unnecessary bankruptcy, both sides can be made better off. *Q.E.D.*